Short Communication

Inbreeding in the Dohne Merino breed in South Africa

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Abstract

The actual level of inbreeding and the effect of inbreeding depression on yearling body weight and fleece traits in the South African Dohne Merino population were investigated. All available pedigree data, which comprised of 266 268 records (302 169 animals including base parents) for the period 1975 to 2003 were used for calculating individual inbreeding coefficients. Inbreeding depression was estimated as the regression of performance (corrected for fixed effects) on the individual and dam inbreeding coefficients, fitting an animal model. The rate of inbreeding (ΔF) was estimated as the difference between the individual inbreeding (F_t) and the inbreeding of the parents (F_{t-1}) divided by ($1-F_{t-1}$). The level of inbreeding (F) in the SA Dohne Merino sheep population is very low. The proportion of animals that was inbred to some extent increased from 0.00 (average F = 0) in 1980 to 0.38 in 2003 (average F = 0.012). No significant inbreeding depression on body weight and fleece traits could be found. In general the results suggest that inbreeding at present is not a serious problem in the South African Dohne Merino breed.

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The accumulation of inbreeding and the consequences thereof have long been a concern in animal breeding. Inbreeding was shown to have a deleterious effect on additive genetic variance as well as on phenotypic values (Falconer & McKay, 1996). The primary consequence of inbreeding at the farm level is inbreeding depression. Inbreeding impairs growth, production, health, fertility and survival. This concern has become more serious in present-day animal breeding, in which selection responses are maximized by the use of animal model best linear unbiased predictors (BLUP) of breeding values. The use of these breeding values alone may result in more closely related selection candidates preferred for selection, with increased levels of inbreeding since they share most of their familial information (Fernandez & Toro, 1999). Nevertheless, the net effect of inbreeding in a selection program will depend on the magnitude of the selection response relative to the possible depression and the rate of accumulation of inbreeding.

Depending on whether genetic gain and inbreeding depression compensate for each other, the level of inbreeding of the animals may need to be accounted for during the selection process. Recent advances in genetic selection programs have greatly increased the annual response to selection, but rates of inbreeding have accordingly increased substantially (Weigel, 2001).

The purpose of this study was to quantify the actual level of inbreeding and to investigate the effect of inbreeding depression on yearling body weight and fleece traits in the South African Dohne Merino population. The Dohne Merino breed is a synthetic breed established *ca.* 1939 in the Eastern Cape Sourveld region of South Africa, from a cross between the Merino and the then German Merino (presently known as the South African Mutton Merino). The original intention was to develop a hardy and versatile genotype that would adapt well to semi-intensive farming practices in this region (Kotzé, 1951). This new breed was also to cope with the seasonal undersupply of nutrients during winter. It was named after the Dohne Research Institute where it was developed.

All available pedigree data, which comprised of 266 268 records (302 169 animals when the base parents were included) for the period 1975 to 2003 were used to calculate individual inbreeding coefficients.

The original pedigree file included animals with only one parent, since these animals might also contribute to the inbreeding coefficients. Animals where parentage was not recorded were omitted. The bigger dataset was used to create as many links as possible between animals to calculate the inbreeding coefficients as accurately as possible. Data obtained for 2004 were still incomplete and not suitable for use in this study. The Dohne Merino Breed Society employs a strategy of upgrading F3 commercial animals, for which no pedigree information is supplied, to the studs. The number of animals entering the dataset in this manner may lead to an underestimation of inbreeding and might therefore have an influence on the outcome of this study.

Firstly all known relationships from the entire dataset were used to calculate individual inbreeding coefficients using the MTDFNRM program of Boldman *et al.* (1995). The rate of inbreeding (ΔF) was estimated as the difference between the inbreeding of the individual (F_t) and the average inbreeding of the parents (F_{t-1}) divided by ($1-F_{t-1}$) (Falconer & McKay, 1996). The effective population size (N_e) was calculated as $1/(2\Delta F)$. The average generation interval was calculated as the mean age of the parents at the time their offspring were born.

Inbreeding depression was estimated as the regression of performance (corrected for fixed effects) on the individual and dam inbreeding coefficients, fitting an animal model. Traits considered were yearling body weight, yearling greasy fleece weight and yearling mean fibre diameter. Linear regression coefficients were estimated using the ASREML program (Gilmour *et al.*, 2002), fitting single-trait animal models.

The number of animals and their average inbreeding coefficients from 1975-2003 are presented in Table 1. According to Table 1 only 18.67% of all the animals were inbred to some extent. No animals born before 1980 were inbred.

Table 1 Data description

	n	% of total	Average level of inbreeding (%)
Total number of animals	302169	100.00	0.64
Non inbred	245768	81.33	0.00
Inbred	56401	18.67	3.43
Number of animals without sires	35901	11.88	-
Number of animals without dams	37026	12.25	-

When all the animals in the study were considered, the average inbreeding coefficient was very low at 0.64%, compared to an average inbreeding coefficient of 3.43% for inbred animals (Table 1). Figure 1 shows the annual proportion of inbred animals from 1980 to 2003. The proportion of inbred animals increased from 0.00 in 1980 to 0.38 in 2003. The proportion of inbred animals in 2003 may be a cause for concern, although the average level of inbreeding was still very low. The maximum individual inbreeding coefficient of animals born in 2003 was 0.32 while 0.032 of these animals had an inbreeding coefficient higher than 0.10. Since 1984 the maximum individual inbreeding coefficients were 25.0% or higher (Fig. 1).

The accumulated average inbreeding for the 24 years from 1980 to 2003 was 1.22%. With an average generation interval of 3.5 years, it was calculated that the period from 1980 to 2003 involved approximately 6.57 generations. Inbreeding therefore seemed to accrue at a rate of 0.186% per generation.

According to Figure 2, the rate of inbreeding in the Dohne Merino breed consistently increased from 1980 to 2003. The regression coefficient (± s.e.) depicting the average rate of inbreeding on birth year was 0.00016 ± 0.00003 ($R^2 = 0.73$) for the period from 1980 to 1994 and 0.00036 ± 0.00006 ($R^2 = 0.84$) for the period from 1995 to 2003. The inbreeding coefficients were very low and did not differ significantly from zero ($P > 0.10$). From about 1994 the increase in inbreeding seemed to accelerate. This appearance might be associated with superior sires being used more widely or possibly because pedigree information was better. The annual average rate of inbreeding was 0.002%. During 2003 the rate of inbreeding was 0.006%.

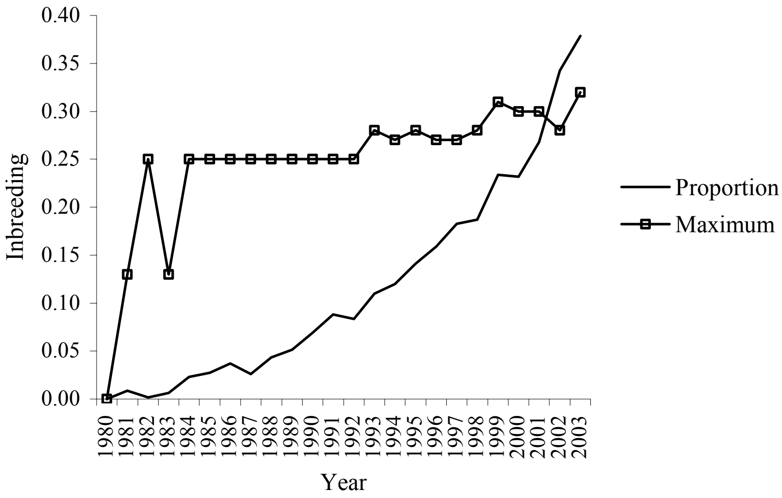

Figure 1 Annual maximum individual levels of inbreeding and annual proportion of inbred animals

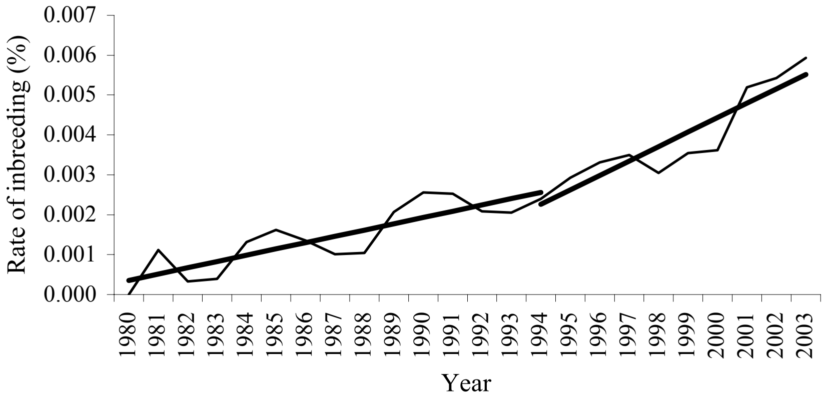

Figure 2 Mean rate of inbreeding (ΔF) within birth year (1980-2003)

Nicholas (1989) suggested that inbreeding rates of up to 0.5% per year should be acceptable in animal breeding programs. It appears that rates of inbreeding in this breed (0.002% annually) are well below the critical levels cited by Nicholas (1989) and consideration of additional methods to avoid inbreeding is not necessary at the present time (Fig. 2).

According to Table 2 there were no significant ($P > 0.05$) effects of inbreeding depression on the traits that were assessed. The high standard errors made any inference on the direction of the estimates speculative and would thus not be discussed in detail. However, literature values for regression coefficients of body weight stated in a review by Lamberson & Thomas (1984) ranged between -0.266 and -0.025. In a study by MacKinnon (2003) the effects of animal or dam inbreeding varied for mean fibre diameter, and none of the regressions were significantly different from zero. Results of the present study were consistent with these literature sources.

A review by Lamberson & Thomas (1984) showed little effect of inbreeding on fleece weight, but inbreeding effects were more prominent in Merino sheep than in other range sheep. According to MacKinnon (2003) it seems that individual inbreeding does not have a large effect on the quality of the fleece, but may slightly decrease fleece weight (i.e. quantity). This is in agreement with the present estimates if the sign of the regressions is considered.

Table 2 Regression coefficients (b ± s.e.) for the different traits on individual inbreeding coefficients of animal and/or dam for a 0.01 change in inbreeding

Trait	Animal		Dam	
	b	P	b	P
Body weight	-0.2145 ± 0.5516	0.7204	0.1277 ± 0.8796	0.6258
Clean fleece weight	-0.0673 ± 0.0549	0.2162	0.0906 ± 0.0876	0.3722
Mean fibre diameter	0.0008 ± 0.1233	0.4870	0.0122 ± 0.1966	0.7336

P > 0.05 = non-significant

In conclusion, it was evident that the average level of inbreeding in the Dohne Merino sheep breed, according to the data analysed in this study was low (0.0064). The proportion of animals that was inbred to some extent increased to a high (0.38) in 2003, while the average level of inbreeding in that year was still very low (0.0122). It appears that rates of inbreeding in the breed (0.0002 per year) are well below the critical levels (0.005 per year) and consideration of additional methods to avoid inbreeding is not necessary at the present time. A possible reason for the low levels of inbreeding might be related to the pattern of exchange of breeding material between studs and by introducing commercial F3 animals to studs as migrants. Roux (1995a; b) indicated that relatively few migrants introduced to a population may have a marked effect on the inbreeding of that population. Based upon relatively low levels of inbreeding and a lack of evidence of significant inbreeding depression in the three traits studied, it is hypothesized that other traits should not be affected deleteriously at present. This situation may change in future, since the rate of inbreeding seemed to accelerate in recent years. Inbreeding in the Dohne Merino breed should be kept under surveillance, since it is accepted that survival and fitness traits are more likely to be affected by inbreeding in sheep than live weight and fleece traits (Lamberson & Thomas, 1984).

References

Boldman, K.G., Kriese, L.A., Van Vleck, L.D., Van Tassell, C.P. & Kachman, S.D., 1995. A manual for use of MTDFREML. A set of programs to obtain estimates of variances and covariances (DRAFT), U.S. Department of Agriculture, Agricultural Research Service.

Falconer, D.S. & Mackay, T.F.C., 1996. Introduction to Quantitative Genetics, Longman, Harlow.

Fernandez, J. & Toro, M.A., 1999. The use of mathematical programming to control inbreeding in selection schemes. J. Anim. Breed. Genet. 116, 447–466.

Gilmour, A.R., Gogel, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 2002. ASREML-User Guide Release 1.0 VSN International Ltd, Hemel Hempstead, HP11ES, UK.

Kotzé, J.J.J., 1951. The development of a mutton-wooled sheep for the Sour-grassveld area. Farming in South Africa. Reprint no. 26, 110-113.

Lamberson, W.R. & Thomas, D.L., 1984. Effects of inbreeding in sheep: a review. Anim. Breed. Abstr. 52 (5), 287-297.

MacKinnon, K.M., 2003. Analysis of inbreeding in a closed population of crossbred sheep. M.Sc. Dissertation, Virginia Polytechnic Institute and State University, USA.

Nicholas, F.W., 1989. Evolution and Animal Breeding. Eds. Hill, W.G. & Mackay, T.F.C., CAB International, Wallingford, UK.

Roux, C.Z., 1995a. Countering inbreeding with migration. 1. Migration from unrelated populations. S. Afr. J. Anim. Sci. 25, 40-43.

Roux, C.Z., 1995b. Countering inbreeding with migration. 2. Migration from related populations. S. Afr. J. Anim. Sci. 25, 44-49.

Weigel, K.A., 2001. Controlling inbreeding in modern breeding programs. J. Dairy Sci. 84 (Supplement E), E177-E184.